

10057
Vesicular Basalt
919 grams

DRAFT□

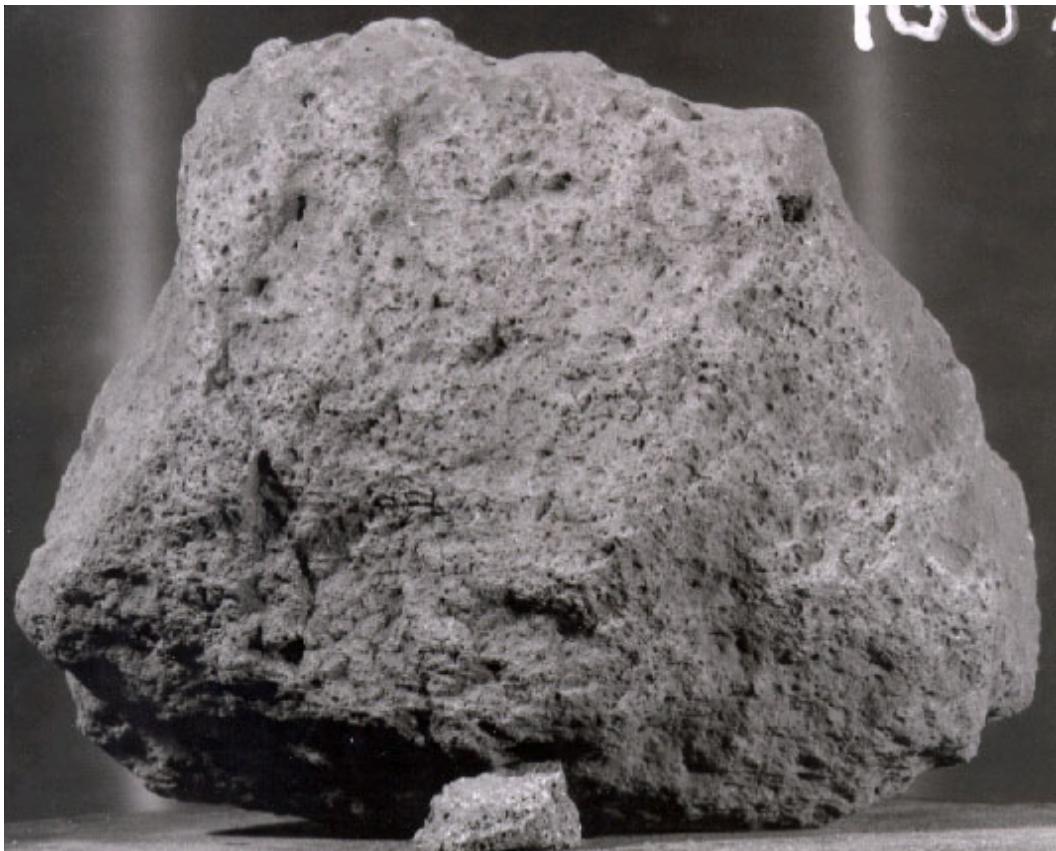


Figure 1: Photo of whole rock 10057,0 during preliminary examination. NASA photo # S69-46287

Introduction

All of the Apollo 11 basalts have high TiO_2 , low SiO_2 content. Apollo 11 did not sample a very wide area and it appears that only 2 lava flows may have been sampled, distinguished by higher K and slightly higher REE contents in one than the other.

10057 belongs to the group of samples known as “high K, Apollo 11 basalts”. Although they range in texture, they are remarkable similar in composition and are probably from the same basalt flow (Beaty and Albee 1978). The range of texture is attributed to differences in cooling rate. 10057 is fine-grained and cooled rather quickly.

Petrography

Lunar basalt 10057 is composed of intergrown subhedral to anhedral plagioclase, euhedral to subhedral ilmenite, subhederal pyroxene and a residual fine-grained mesostasis composed of plagioclase,

cristobalite and potassic glass. 10057 has a high abundance (~10%) of vesicles (figure 1). LSPET 1969 termed this group of vesicular, fine-grained rock “type A basalts”. James and Wright (1972) termed these rocks “intersertal ilmenite basalts”.

Mineralogy

Pyroxene: Pyroxenes in 10057 are chemically zoned in major and minor elements (Lovering and Ware 1970, Essene et al. 1970 and Beaty and Albee 1978) (figure 3). Large grains have pigeonite cores with augite rims trending towards iron rich.

Plagioclase: □The plagioclase in 10057 ranges in composition from An_{74} to An_{81} (Reid et al. 1970, Beaty and Albee 1978).

Opaques: Ilmenite in 10057 is about the same size as pyroxene or plagioclase.

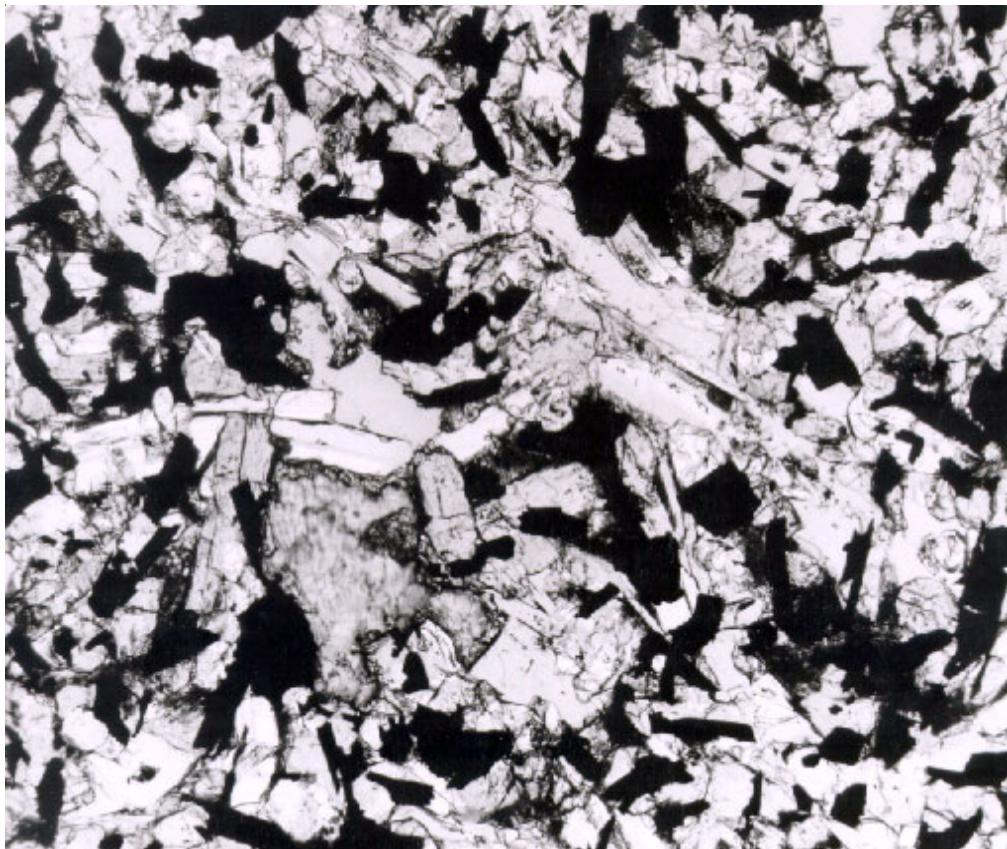


Figure 2: Photomicrograph of thin section of 10057 (plane polarized light). NASA #76-26315.

Chemistry

Lunar basalt 10057 was widely distributed and analyzed by numerous persons (tables 1, 2). Figures 4 and 5 show that 10057 is a typical high-K, high-Ti Apollo 11 basalt.

Radiogenic age dating

Papanastassiou et al. (1970) dated 10057 as 3.63 ± 0.002 b.y. by the Rb-Sr method.

Cosmogenic isotopes and exposure ages

O'Kelly et al. (1970), Perkins et al. (1970) and Wrigley and Quaide (1970) measured significant ^{22}Na , ^{26}Al , ^{46}Sc , ^{54}Mn , and ^{56}Co (all short half lives) in 10057 due to recent cosmic ray events.

The exposure ages for 10057 were reviewed by Hintenberger et al. (1971). Hohenberg et al. (1970) determined 34 ± 5 m.y. by ^{81}Kr , Marti (1970) and Marti and Lugmair (1971) determined 47 m.y. by ^{81}Kr ,

Mineralogical Mode for 10057

	Haggerty et al. 1970	Beaty and Albee 1978
Olivine		<0.04
Pyroxene	50.9 vol. %	50.8
Plagioclase	19.2	24
Opaques	15.7	15.5
Cristobalite		1.05
Troilite		0.42
Phosphate		0.21
Mesostasis		8.04
Metal		0.04
Vesicles	11	absent
Armalcolite		

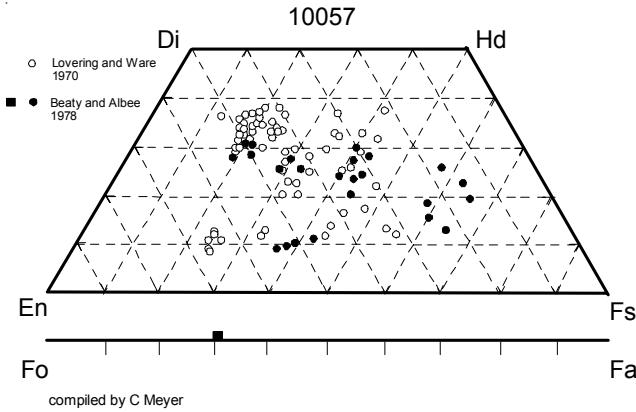


Figure 3: Olivine and pyroxene composition diagram for 10057 (data replotted from Lovering and Ware 1970 and Beatty and Albee 1977).

Bochsler et al. (1971) reported 52.5 m.y. and Hintenberger et al. (1971) determined 58 m.y. by ^{38}Ar .

Other Studies

The rare gas content and isotopic ratio were reported by Hohenberg et al. (1970), Hintenberger et al. (1971).

Processing

A piece of 10057 (large area thin section) is in the center of the Space Window of the National Cathedral (figures 6 and 7).

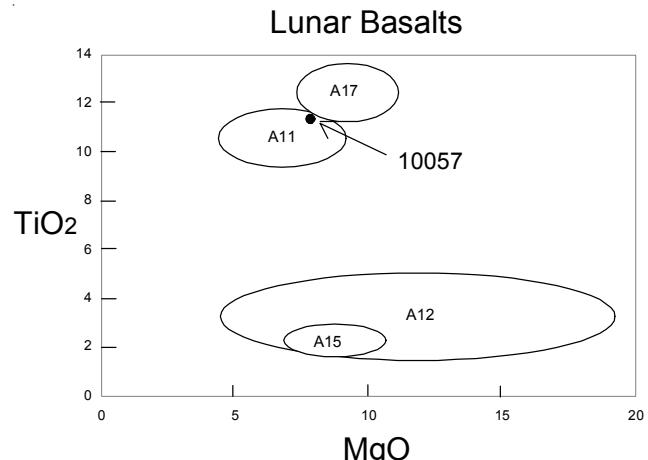


Figure 4: Composition of lunar basalts showing position for 10057 (data from table 1).

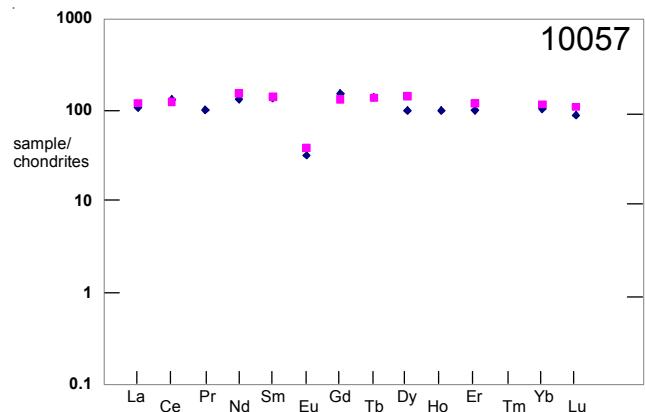


Figure 5: Normalized rare-earth-element diagram for 10057 (data from Wanke et al. 1970 and Haskin et al. 1970 only).

Summary of Age Data for 10057

Papanastassiou et al. 1970

Rb-Sr

3.63 ± 0.002

Ar-Ar

K-Ar

Table 1a. Chemical composition of 10057.

reference weight	Engel 70	Wanke 70	Wasson 70	Wrigley 70	Ganapathy 70	Anders 71	Morrison 70	Perkins 70	O'Kelly 70
SiO ₂ %	39.79	(a)	40.43				46	(d)	
TiO ₂	11.44	(a)	10.84	(b)			7.56	(b)	
Al ₂ O ₃	10.84	(a)	7.56	(b)			10.84	(b)	
FeO	19.35	(a)	18.01	(b)			20.2	(b)	
MnO	0.2	(a)	0.23	(b)			0.22	(b)	
MgO	7.65	(a)	6.96	(b)			6.13	(b)	
CaO	10.08	(a)	11.75	(b)			14.13	(b)	
Na ₂ O	0.54	(a)	0.4	(b)			0.47	(b)	
K ₂ O	0.32	(a)	0.24	(b)			0.26	(b)	0.28 (e) 0.31 (e)
P ₂ O ₅	0.17	(a)					0.09	(c)	
S %									
<i>sum</i>									
Sc ppm	100	(f)	87	(b)			84	(b)	
V	66	(f)					40	(b)	
Cr	2400	(f)	2160	(b)			2100	(b)	
Co	21	(f)	25.4	(b)	27.2	(b)	30	(b)	24 (b)
Ni	7	(f)	<10	(b)				40	(b)
Cu	11	(f)	4.3	(b)	3.52	(b)		5.5	(b)
Zn					1.7	(b)	1.75	(b)	2.9 (b)
Ga			5.2	(b)				4.7	
Ge ppb				< 70	(b)				
As									
Se						0.181	(b)		
Rb			5.2	(b)	3.68	(b)		4.8	(b)
Sr	130	(f)	100	(b)				130	(b)
Y	180	(f)						210	(c)
Zr	400	(f)			560	(b)		360	(b)
Nb								42	(c)
Mo							0.4	(b)	
Ru									
Rh									
Pd ppb			10	(b)	7.3	(b)			
Ag ppb					0.69	(b)			
Cd ppb					3.15	(b)	3.5	(b)	
In ppb			2.7	(b)	3	(b)			
Sn ppb					3.2	(b)			
Sb ppb									
Te ppb					8	(b)			
Cs ppm			0.2	(b)	0.159	(b)		0.2	(b)
Ba	130	(f)	208	(b)				280	(b)
La			25	(b)				31	(b)
Ce			79	(b)				83	(b)
Pr			9	(b)				22	(c)
Nd			60	(b)				66	(b)
Sm			20	(b)				24	(b)
Eu			1.8	(b)				2.1	(b)
Gd			30	(b)				26	(b)
Tb			5	(b)				5.6	(b)
Dy			24	(b)				42	(c)
Ho			5.5	(b)				8	(b)
Er			16	(b)				32	(c)
Tm								2.3	(b)
Yb	16	(f)	16.8	(b)				26	(b)
Lu			2.15	(b)				2.2	(b)
Hf			16.9	(b)				15	(b)
Ta			2	(b)				1.2	(b)
W ppb			430	(b)				0.42	(b)
Re ppb									
Os ppb									
Ir ppb			0.1		0.023	(b)	0.009	(b)	
Pt ppb									
Au ppb			1.6	< 0.3	0.017	(b)	0.013	(b)	
Th ppm			3.94	(b)	3.27	(b)		4.5	(b)
U ppm			0.8	(b)	0.97	(b)		0.56	(b)

technique (a) wet chem. (b) INAA, RNAA, (c) SSMS, (d) AA, (e) radiation counting, (f) emission spec.

Table 1b. Chemical composition of 10057.

reference	Smales 71	Kharkar 71	Annell 70	Tatsumoto 70	Haskin 70	Baedecker 70	LSPET 70
weight							
SiO ₂ %	41.4				36	(c)	
TiO ₂	10.9	12.18	(b)		12.5	(c)	
Al ₂ O ₃	8.1				11	(c)	
FeO	19.1	18.65	(b)		20	(c)	
MnO	0.23	0.23	(b)	0.28		0.49	(c)
MgO	7.4					9.5	(c)
CaO	10.4	9.37	(b)			10	(c)
Na ₂ O	0.54	0.55	(b)			0.54	(c)
K ₂ O	0.33					0.18	(c)
P ₂ O ₅							
S %							
sum							
Sc ppm	86	90	(b)	99		110	(c)
V				65		50	(c)
Cr	2250	2290	(b)	2790		6500	(c)
Co		26	(b)	30		22	(c)
Ni				6.1		25	(c)
Cu				5.7			
Zn							
Ga				5		4.9	(b)
Ge ppb					<0.2	(b)	
As							
Se							
Rb				4.7		6	(c)
Sr				140		230	(c)
Y				165		310	(c)
Zr				635			
Nb				29			
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb							
Cd ppb							
In ppb					3	(b)	
Sn ppb							
Sb ppb							
Te ppb							
Cs ppm							
Ba			440			180	(c)
La	23	(b)	26		28.2	(b)	
Ce	69.6	(b)			75	(b)	
Pr							
Nd				69	(b)		
Sm	14.3	(b)		20.8	(b)		
Eu	2.4	(b)		2.18	(b)		
Gd				26	(b)		
Tb				5	(b)		
Dy	29.9	(b)		34.7	(b)		
Ho							
Er				19	(b)		
Tm							
Yb	13.2	(b)		18.8	(b)	6	(c)
Lu	2.48	(b)		2.66	(b)		
Hf	18.1	(b)					
Ta	1.7	(b)					
W ppb							
Re ppb							
Os ppb							
Ir ppb							
Pt ppb							
Au ppb							
Th ppm				3.415	(a)		
U ppm				0.865	(a)		

technique (a) IDMS, (b) INAA, (c) emission spec.

Table 2. Light and/or volatile elements for 10057

	Engel 70	Wanke 70	Annell 70	Morrison 70	Ganapathy 70
Li ppm	14	14	17	8	
Be			3.3	2.5	
B		0.8		4	
C					
S					
F ppm			70		
Cl		12		50	
Br ppb				100	25.2
I					
Pb ppm					
Hg ppb					
Tl ppb				1.09	
Bi ppb				0.27	



Figure 6: Space Window at US National Cathedral in Washington DC with piece of 10057 located in center of rose window.

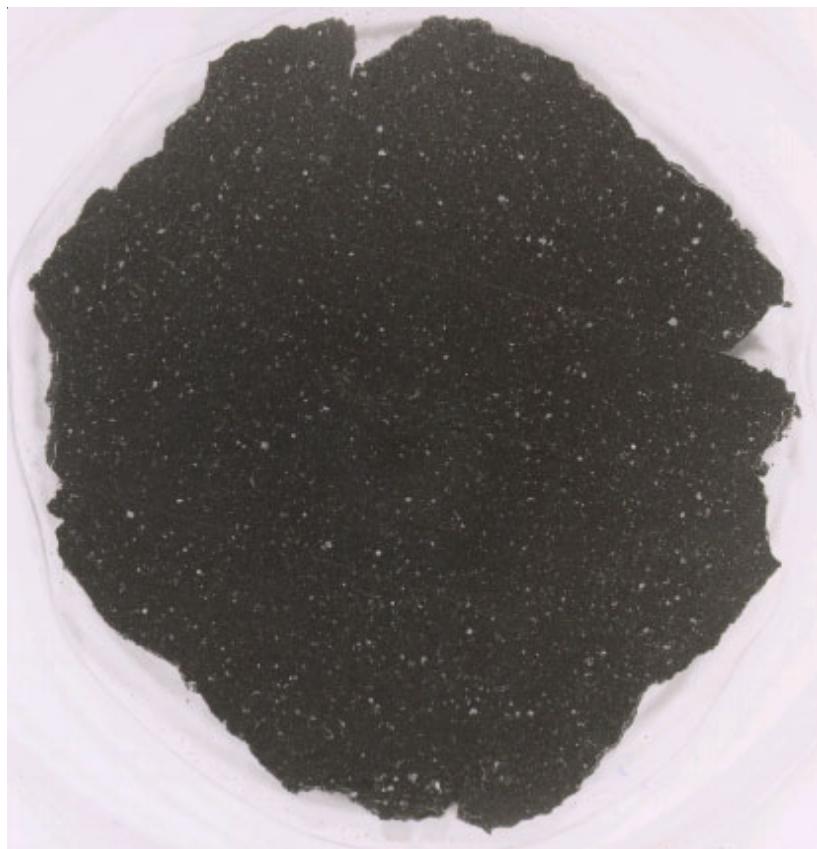


Figure 7: Photo of thin slice of 10057 located in Space Window.